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Essay 1

An Empirical Analysis of the Impact of Credit Default Swap Rates on Short-Term Interest Rates

Abstract

In this study, we empirically investigate the impact of credit default swap rates on short-term interest rates. We find that CDS rates significantly impact short-term interest rates. The impact remains significant after controlling for inflation and unemployment. Applying co-integration test and vector error correction modeling, the study also finds a causal relationship between CDS rates and short-term interest rates. These relationships are confirmed through autoregressive conditional heteroscedasticity (ARCH), exponential generalized ARCH [EGARCH] and vector auto-regression (VAR) analyses. The empirical results have important implications in setting short-term interest rates. A regular revision of policy targeting to capture the continual changes in CDS rates is inferred.

Keywords: Derivatives, Federal Funds Rates, OLS, ARCH, EGARCH, VAR

JEL Classification: C320, E520, E580, G210

1.0 INTRODUCTION

This study examines the impact of credit default swaps (CDS) rates on short-term interest rates policy. CDS is essentially an insurance policy that protects a buyer against the loss of principal on a bond in case of a default by the insurer. The buyer of the CDS is obliged to pay periodic premium to the seller over the life of the contract. The use of credit default swaps increased over time. Between 2002 and 2007, gross notional amounts outstanding grew from below USD 2 trillion to nearly USD 60 trillion. By the end of 2007, the outstanding amount was $62.2 trillion, falling to $38.6 trillion by the end of 2008. Currently, CDS is the dominant credit derivative with almost 50% market share. The primary purpose of a credit default swap contract is to provide protection to the purchaser of a debt instrument in case of default or a related credit event, serving as credit quality, or to hedge a long position in the debt or equity of a reference entity. An investor in a CDS contract pays an annual premium to the seller of the contract. If a credit event such as default of the underlying reference entity occurs, the seller buys the underlying debt instrument from the investor at par. The annual premium thus reflects the market price of the credit risk with respect to the underlying instrument.

Over the last few years, large-scale use of financial derivatives including CDS, has become a key feature of financial markets and this utilization continues to grow. The unprecedented pace and growth of these financial derivatives has been a driving force in the financial system. In fact, Townend (1995) reported that the growth and use of derivatives has impacted the quality indicator of monetary policy including monetary and credit aggregates.

There are several ways in which the growth of derivatives has impacted the short-term interest rates and monetary policy. Firstly, derivatives have changed the demand for money, as evidenced by reduced transaction costs, and low-cost risk management alternatives which reduces the speculative demand for money (Mullins, 1997). Secondly, derivatives provide competing alternatives to the broader monetary aggregates; this is because the low-cost hedging of the price risk of traded assets has transformed market instruments into lower-risk instruments that compete with interest-bearing components of the broad-aggregates (Mullins, 1997). Thirdly, the growth and use of derivatives has also impacted credit aggregates through its impacts on the improvements in risk management. This capability enables banks to lend out more flexible credit alternatives on improved terms to borrowers.

1.1 Overview of Financial Derivative Products

Derivatives comprise a broad range of products that impute their values from varying asset classes. They include equity, interest rate, commodity, foreign exchange and credit derivatives. Equity futures and options on broad equity indices are the most commonly cited equity derivatives. They are useful hedging instruments. Trading in these products commenced in 1982. Other traded equity derivatives are equity-swaps in which an investor pays the return on a stock and receives in return a floating rate. Interest rate swap is the most popular interest rate derivative. Here, for example, a bank may agree to make payments to a counterparty based on a floating rate in exchange for a fixed interest rate payment. In another form, interest rate futures contract allows a buyer to lock in a future investment rate. This is useful due to their ability to provide information on market expectations of future monetary policy decisions by the Federal

Reserve in the US (Carlson et al 2006). Credit derivatives are touted as the earliest market because of problems encountered with storage, delivery and seasonal patterns. It allows price volatility to be effectively hedged to better reflect the market supply and demand situations.

Foreign exchange derivatives arose due to the increasing financial and trade integration across countries. Participants demanded protection against exchange rate movements. A forward exchange contract is stated as the popular tool for hedging. Another type is the use of cross-currency swaps in which parties involved exchange payments of principals and interest in different currencies.

Finally, credit derivatives come into play when a participant makes a promise to pay another contingent upon the occurrence of a credit event. The credit event could be failing to pay, filing for bankruptcy, etc. The fastest growing among credit derivatives is the credit default swaps (CDS). Hence this essay focuses on the impact of CDS rates on short-term interest rates policy.

1.2 Overview of Federal Funds Rates (Short-Term Interest Rates)

The short-term interest rates are of fundamental importance to financial markets. Interest rates are key inputs into the valuation of securities that are traded in the financial markets. Theoretical research has sought to understand short term interest rates. Empirical research on interest rates include valuation, prediction and hedging.

The Federal Reserve Bank (Fed) is charged with maintaining the stability of the nation's financial system and takes actions to raise or lower short-term interest rates in an effort to keep the economy stable. When the Fed cuts short-term rates, it does so by cutting the rate that banks charge each other to borrow money. The rate reduction is eventually passed on to businesses and consumers. The same thing happens in the reverse when the Fed raises short-term rates.

In a growing economy, companies become more profitable, there is low unemployment rate and consumers' spending increases. In such situations, the Fed acts to raise short-term rates to prevent inflation. However, raising interest rates slows the economy. Higher interest rates mean higher borrowing costs for individuals and businesses, and that usually means there is less money to spend elsewhere.

On the other hand, when the economy is contracting, the Fed nudges short-term rates lower. Lowering rates makes it less expensive to borrow money. Consumers and businesses can afford to buy more products and services. That speeds up the economy, keeps people employed, and keeps the economy from sinking into a recession.

1.3 Derivatives Impact on Federal Funds Rates (Short-Term Interest Rates)

Interest rates are the main transmission mechanism of monetary policy. A tightening of monetary policy leads to an increase in the nominal interest rate, which in turn translates to an increase in the real interest rate due to price stickiness. This real interest rate increase reduces investment and consequently output falls.

A growing number of studies have argued that derivatives increase the speed with which monetary policy actions are transmitted through the financial system. Vrolijk (1997) analyzed the effect of the broader derivatives markets on the channels of monetary policy transmission. He argues that derivatives trading speeds up the effect of policy transmission on financial asset prices. This is because of the derivatives' ability to lower transaction cost and reduce frictions. As such, new information is easily incorporated into asset prices. This effect is supported by Cohen (1996), who found that derivatives accelerate the incorporation of new information into asset prices. Mullins (1997) concluded that derivatives have increased the liquidity, depth, flexibility and transactional efficiency of foreign markets thereby enhancing trading and hedging opportunities.

The transmission mechanisms of monetary policy work through various channels, affecting different variables and different markets at various speeds, which can be intensified by the presence of derivatives. As indicated earlier, the main channel is the short-term interest rates. Although derivatives may affect the relation between interest rates and aggregate spending through the redistribution of risk, the sensitivity of spending is affected to the extent derivative can facilitate the shifting of the risk.

From the above overviews, it is apparent that the derivative market is well established yet studies of the impacts of the market on the link between short-term interest rates policy induced changes in the financial variables, aggregate spending and inflation have resulted in less substantial conclusions. It seems natural to query whether large policy actions would be necessary to achieve a target result for aggregate spending. A second query appears to be should the setting of interest rates be re-examined or recalibrated to reflect the effectiveness of innovations in financial and economic environments? It is time policy makers re-examined the impact of derivative markets on policy because several studies have shown various impacts on different financial market and products. The rationale of the study is threefold: to inform short-term interest rates policy formulation and interventions, to understand the behavior of interest rates policy due to changes in the financial sector and the need for central banks to monitor developments in financial innovation.

The empirical results yield some interesting findings on the impact of CDS rates on short-term interest rates. First, the results indicate a negative relation between fed funds rates (short-term rates) and CDS rates even after controlling for inflation and unemployment. The regression model improves with the introduction of auto-regression that accounted for almost 30% persistency. Vector error correction modeling indicates both short and long run association between CDS rates and the short-term interest rates. Finally, the study finds that these results are confirmed with ARCH/EGARCH and impulse response analysis. The study also finds that in setting short-term interest rates, central banks need to closely monitor the financial markets.

The study contributes to existing literature in several ways. First, the study extends the literature on the roles of CDS rates on short-term fed funds rates. Second, these findings contribute to literature on the need for central banks to understand the behavior of fed fund rates due to changes in the financial sector.

The remainder of the paper is organized as follows. Section II of the paper presents literature review covering available papers on the subject. Section III discusses the data description and summary statistics. Section 4 presents the econometric analyses conducted and discusses the results from the analyses. The Conclusion, Section IV, presents summary, findings of the study and provides some policy recommendations.

2.0 RELATED LITERATURE

Financial innovation has been a driving force in the financial system. Tufano (2002) broadly categorizes financial innovations into two types, product and process innovations. Product innovation can be illustrated by corporate securities or derivative contracts, while process innovation can be demonstrated by new means of distributing securities, processing transactions or payment system technologies. The emergence of financial derivatives is perhaps the most notable financial innovation. Since derivatives play a crucial role in risk management, they exert considerable influence on the effectiveness of monetary policy, which works through the financial system and its efficacy requires a stable and functioning market place.

Financial innovation has widespread impact on the effectiveness of monetary policy. For example, per Singh *et al* (2008), the use of derivatives has two important implications for monetary transmission. First, it may improve transmission by extending the impact of changes in policy rates from short-term interest rates to the prices of assets in other markets as derivatives increase asset substitutability across financial markets. A second implication of the greater use of derivatives is that it may help create a less abrupt or extreme financial market reaction to monetary policy changes because these instruments are designed to help hedge firms from unexpected changes in their revenues and debt-servicing costs.

Fender (2000) investigated the impact of corporate risk management strategies on monetary policy transmission. He used a single model of a broad credit channel of monetary policy transmission to argue that information asymmetries create incentives for corporate hedging programs. These policies in turn diminish the impact of monetary measures and is reduced to a cost of capital effect. In an earlier related study, Froot *et al* (1993) had shown that if information asymmetries increase the cost of external finance, incentives are created for firms to manage corporate risk. Derivative instruments allow firms to manage such financial risk in a way that grant them protection against changes in the monetary policy stance thereby reducing the real effects of monetary policy.

Hirtle (2009) explores whether the use of credit derivatives is associated with an increase in bank credit supply. He found limited evidence, thereby concluding that the benefits of the growth in credit derivatives may be narrow. This finding is supported by Goderies *et at* (2001). They found that banks that adopted advanced credit risk management techniques experience a permanent increase in their target loans levels of around 50%.

Gomez *et al* (2005) studied derivatives markets' impact on Colombian monetary policy. Utilizing an investment model, the impact of the use of interest rate and exchange rate derivatives in the dilution of the Colombian monetary channels is verified. However, their empirical study suggests that monetary policy lost effectiveness only in the short run. In a similar study, Loutskina and Straha (2006) and Edwards and Mishkin (1996) also find evidence of the weakening of bank lending with the advent of financial innovation such as derivative instruments.

Studies by Ignazio (2007) indicate that financial innovation has opened up new opportunities in the financial sector and have increased markets participants. These developments have increased the range of financing and investments, and have also changed the role of banks to include expanded diversification in terms of their portfolios and sources of liquidation. Such developments have affected the speed and strength of monetary policy transmission in the economy. This has resulted in more complete and liquid financial markets. Changes in interest rates are more readily transmitted to the whole term structure and more generally to asset prices. The increasing use of financial and non-financial assets in firms and households implies that the effect of monetary policy through changes in asset prices and related wealth effects are likely becoming larger while weakening the bank lending channel. This is, in part, because a wide range of borrowers are now able to use financial markets as a substitute for sources of funding. The relevance of the bank lending channel is thus affected negatively by the emergence of non-bank lenders.

Per Noyer (2007), financial innovation fosters rapid dissemination of information and its faster incorporation into the financial markets. This is especially true for monetary policy decisions and can therefore increase the effectiveness of monetary policy transmission, particularly, via the interest rate channel. In addition, Noyer (2007) indicates that financial innovation contributes to an increased holding of financial assets by lowering transaction costs and facilitating arbitrage, hedging, funding and investment strategies. Financial innovation also gives firms broader access to securities markets, which may reduce information asymmetries at the source of the credit channel and therefore weakens this channel. Also, financial innovation, per Noyer (2007), results in greater integration of domestic and international markets. This should strengthen the exchange rate channel as exchange rates become more sensitive to interest rates differential between currency areas.

Ho (2006) examined the linkages among financial innovation, growth and monetary policy transmission mechanisms. The author identifies interest rate channel, exchange rate channel and asset channel as the three main channels through which financial innovation can affect monetary policy. He argues that monetary policy targeted at aspects of macroeconomic variables is essentially a financial process, with the financial system as the interface linking central banks policies and the real economy through monetary policy transmission mechanisms. Hence, any innovative development that affects the structure and conditions of financial markets will have the potential to also influence transmission mechanisms. Ho (2009) further indicates that financial innovation influences the structure of financial markets, the financial behavior of economic agents and the types of financial products traded. It therefore influences the entire monetary transmission mechanism, and adds uncertainty to the financial environment in which central bank conducts monetary operations.

Resina (2004) appears to agree with Ignazio's (2007) findings by contending that financial innovation tends to make existing relation between monetary and non-monetary variables much more unstable and unpredictable. This is because the range of financial assets available and their increased substitutability have made monetary aggregates difficult to interpret. Thus, there has been a trend toward downgrading quantitative targets and focusing on levels of interest rates and exchange rates. Therefore, in a changing financial environment, it is inappropriate to use any one monetary variable as the sole guide for monetary policy.

Sang (2005) indicates that the effectiveness of monetary policy transmission mechanism hinges on changing forms and character of financial diversity and the depth of financial markets. In this context, the author indicates that with the increasing role of capital markets, investors have greater option to diversify their financing away from banks through the issuing of bonds and equities. Accordingly, such changes in the financial system impact the effectiveness of monetary policy.

In another study, Singh *et al* (2008) examined how monetary transmission mechanism is affected by financial development. In this empirical study, the authors used two-step Engle-Granger ECM approach to obtain a long-run relationship between market rate of interest and policy rate. The authors then used simple cross-country correlations to gauge the strength of the association between interest rate pass-through and various measures of financial developments including financial innovation indicators. They found that financial market development strengthens the asset price channel, weakens impact of monetary policy on bank lending channel and has mixed impact on the balance sheet channel. According to their results, financial market development leads to faster and larger interest rate pass through. While some aspects of financial market development strengthen the interest rate channel, advancement of payment technology which enables consumption smoothening weakens the importance of the interest rate channel.

In summary, the related literature review indicates that financial innovation have widespread impacts on interest rates transmission mechanisms with disparate implications on their effectiveness. Financial innovations create new products and systems of financial services delivery that should not be ignored in the setting of short-term interest rates. It is imperative to understand how interest rates policy affects the economy at a point in time, and policy-makers must have an accurate assessment of the timing and effect of their policies on the economy. Hence this study will seek to interpret how the increasing and varied use of derivative products, in particular CDS rates, can inform the setting of short-term interest rates policy.

This paper aims to extend the existing literature by examining how CDS rates influence the short-term interest rates policy. It is important that the real effects of CDS rates shocks are well understood and considered by central banks in policy formulation.

3.0 DATA DESCRIPTION AND SUMMARY STATISTICS

The choice of variables in this study is driven by a recursive identification strategy, as in Hamilton and Jorda (2002). The recursive identification strategy allows one to see whether there is any evidence that short-term interest rates policy has changed over time. Other variables included in the analysis are motivated by consideration of macroeconomic variables that are likely to influence policy objectives. Accordingly, the model uses monthly data on the logarithm of CDS rates, effective federal funds rate, logarithm of inflation, and unemployment (as indicated by total nonfarm payrolls in percent change). The data used in the study covered the period November 2005 to August 2016. Monthly short-term interest rates policy data were obtained from the Federal Reserve Economic Database [FRED] and monthly CDS rates data from Bloomberg.

The results indicate that over the study period, short-term interest rates, CDS rates, inflation and unemployment had, respectively, means of 1.27, 89.52, 94.35 and 0.06. Computations of standard deviations resulted in 1.94, 40.20, 5.55 and 0.19 for the short-term interest rates, CDS rates, inflation and unemployment, respectively. Table 1 presents the descriptive statistics of all the variables used in the study. To depict the variations of the policy variables over the study period, plots are provided in Illustrations 1 and 2.

Table 1 - Descriptive Statistics

Summary statistics of policy variables. The mean, standard deviation, minimum and maximum values of monthly data for fed funds rates, derivatives, inflation and unemployment are presented.

	No. of Observations	Mean	Median	Maximum	Minimum	Standard Deviation
Federal Funds Rate (fedfunds)	130	1.27	0.16	5.26	0.07	1.94
CDS Rates (cds)	130	89.52	85.31	238.6	31.43	40.20
Inflation (inflation)	130	94.35	95.90	101.70	83.23	5.55
Unemployment (unemploy)	130	0.06	0.11	0.40	0.00	0.19

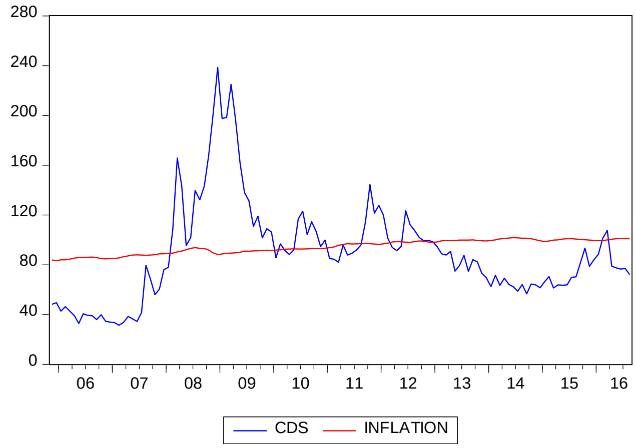

Illustration 1 – Variation of Derivatives and Inflation Over Study Period

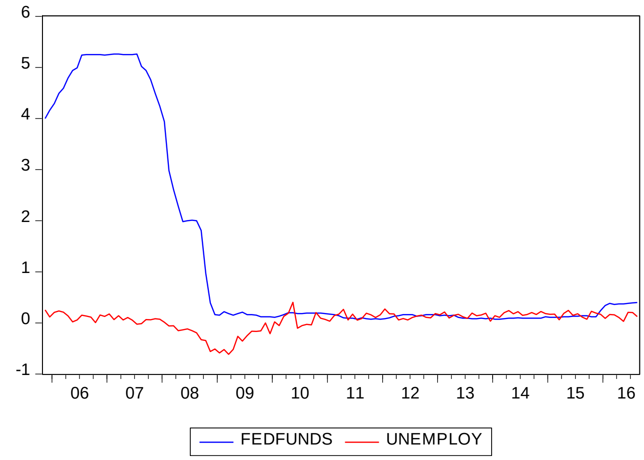

Illustration 2 – Variation of Federal Funds Rate and Unemployment Over Study Period

4.0 EMPIRICAL TESTS AND DISCUSSION OF RESULTS

Correlation

First a correlation test was conducted among the variables. This is to test and avoid multi-collinearity in the estimated model. The correlation results are presented in Table 2 below.

Table 2 – Correlation Analysis

Pairwise correlation of variables utilized in the study.

	FEDFUNDS	CDS	INFLATION	UNEMPLOY
FEDFUNDS	1	-0.491837	-0.788093	0.04106400
CDS	-0.491837	1	0.0420011	-0.740771
INFLATION	-0.788093	0.0420011	1	0.361260
UNEMPLOY	0.04106400	-0.740771	0.361260	1

Stationarity of Variables

Since the study used monthly data over a longer period from 2005 to 2016 it was important to test for the stationarity of the variables. This is characterized by the Unit Root Test Process. The Augmented Dickey Fuller Test is the preferred method of unit root test. The data at levels are not stationary but all became stationary at the First (1^{st}) Difference. D(variable) as utilized in this study transforms the variables to 1^{st} difference.

Ordinary Least Square Regression (OLS)

I first examined how CDS rates, inflation and unemployment impact the short-term interest rates by utilizing the following regression models:

$$fedfunds = \propto\ + \beta 1(\Delta CDS) +\ ut \qquad (1)$$

$$fedfunds = \propto\ + \beta 1(\Delta CDS) +\ \beta 2(\Delta inflation) +\ \beta 3(unemploy) +\ ut \qquad (2)$$

Where fedfunds is the short-term interest rates, ΔCDS is the change in credit default swaps rates, unemploy is the unemployment rate (as indicated by total nonfarm payrolls) and ut is the error term. α, is the regression intercept, β1, β2 and β3 are the coefficients of the independent variables. Equation (1) is the base model and equation (2) controls for inflation and unemployment.

Utilizing the above models, a conventional regression analysis using ordinary least squares (OLS) is ran to ascertain a relation between fedfunds, CDS rates, inflation and unemployment for the monthly data from 2005 to 2016. The empirical results are presented in Tables 2 and 3 below. As seen in the Tables, interest rates and CDS rates move in opposite directions. However, the p-value indicates that CDS rates are highly significant in impacting the short-term interest rates.

Table 3 – OLS Regression Output of Base Model

Dependent Variable: D(FEDFUNDS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.026913	0.012654	-2.126832	0.0354
D(LOG(CDS))	-0.320065	0.089279	-3.585002	0.0005
R-squared	0.091899			
Prob(F-statistic)	0.000479			

Table 4 – OLS Regression Output of Controlling Model

Dependent Variable: D(FEDFUNDS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.032765	0.013078	-2.505301	0.0135
D(LOG(CDS))	-0.268832	0.092634	-2.902097	0.0044
D(LOG(INFLATION))	4.013502	2.436160	1.647471	0.1020
D(UNEMPLOY)	0.096136	0.128961	0.745464	0.4574
R-squared	0.117855			
Prob(F-statistic)	0.001284			

Auto-Regression Analysis

Although the OLS resulted in a robust model, an auto-regression (AR) model was also estimated. As can be seen in Tables 5 and 6 below, AR(8) fits very well the time series residuals. Thus, the time series residuals exhibit an auto-regression with up to eight (8) lags. Also from Tables 5 and 6, a decrease in CDS rates results in increasing in short term rates. In other words, a tightening of short-term interest rates results in a decrease in CDS rates. It is seen that both reactions show much significance with p-values less than 5%. The AR(8) component implies about 39% persistency in the monthly short-term rates.

Table 5 – OLS Regression Output of Base Model with Auto-Regression

Dependent Variable: D(FEDFUNDS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.019270	0.025787	-0.747252	0.4563
D(LOG(CDS))	-0.244926	0.064830	-3.777970	0.0002
AR(8)	0.385432	0.041007	9.399186	0.0000
R-squared	0.222428			
Prob(F-statistic)	0.000001			

Table 6 – OLS Regression Output of Controlling Model with Auto-Regression

Dependent Variable: D(FEDFUNDS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.024431	0.026857	-0.909646	0.3648
D(LOG(CDS))	-0.199613	0.064599	-3.090009	0.0025
D(LOG(INFLATION))	3.444731	1.464968	2.351404	0.0203
D(UNEMPLOY)	0.048748	0.165627	0.294326	0.7690
AR(8)	0.387079	0.048771	7.936669	0.0000
R-squared	0.243639			
Prob(F-statistic)	0.000002			

The existence of correlation does not imply causality nor co-integration. These are aspects that will be analyzed in the next sections.

Co-Integration Test

The purpose of this test is to ascertain whether the variables are co-integrated in the short or long run. Lag intervals in the 1st difference were used in this test. Johansen Test was utilized in this analysis. Outputs from the Co-Integration Test are given in the Appendix. The results indicate co-integration among the variables exist. Tables 7 and 8 present the co-integration analysis.

Table 7 – Co-integration Test for Base Model

Series: FEDFUNDS LOG(CDS)
Lags interval (in first differences): 1 to 13

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.108219	18.51147	15.49471	0.0170
At most 1 *	0.044048	5.225505	3.841466	0.0223

Trace test indicates 2 co-integrating eqn(s) at the 0.05 level

Table 8 – Co-integration Model for Controlling Model

Series: FEDFUNDS CDS INFLATION UNEMPLOY
Lags interval (in first differences): 1 to 13

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.301438	78.58313	47.85613	0.0000
At most 1 *	0.162962	36.97023	29.79707	0.0063
At most 2 *	0.070969	16.33546	15.49471	0.0373
At most 3 *	0.065001	7.796302	3.841466	0.0052

Trace test indicates 4 co-integrating eqn(s) at the 0.05 level

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.301438	41.61290	27.58434	0.0004
At most 1	0.162962	20.63477	21.13162	0.0585
At most 2	0.070969	8.539159	14.26460	0.3265
At most 3 *	0.065001	7.796302	3.841466	0.0052

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

Causality Analysis

Vector Error Correction Model

With co-integration established, the VECM was run on the variables to determine causality between the short-term interest rates and CDS rates. This was achieved by developing a Model with short term interest rates as the dependent variable and CDS rates as the independent variables. As can be seen from Table 9 below, the coefficients of the error terms (C1) are all negative. These suggest that the variables have a long run causality relationship from CDS rates to short term interest rates. However, for the controlling model specification, the coefficient is insignificant since its p-value of 46.49% is greater than 5%.

For the model developed a co-efficient diagnosis analysis was then conducted to ascertain either a short run or long run causality using the Wald Test. With probabilities, greater than 5%, the results indicate that CDS rates influence short term interest rates also in the short run. The results of the Wald Test are also provided in the Appendix.

Table 9 – Vector Error Correction Modeling

In the base and controlling models, the coefficients are negative and significant only for the base model. This implies long run causality running from CDS to FFR. Thus, CDS influence short term interest rates in the long run with the causality running from CDS to short-term interest rates.

	Base Model (C1)	Probability (R^2)	Controlling Model (C1)	Probability (R^2)
CDS Rates	-0.007892	0.0042 (71.06%)	-0.003130	0.4649 (80.35%)

ARCH / EGARCH Analysis

Examination of the regression residuals plot below suggests that the residuals exhibit volatility clustering, that is variability is smaller for earlier years before the financial crisis, increased apparently during the crisis and return to minimal variability thereafter. As such, an EGARCH(1,1) model specification was assumed appropriate for the series.

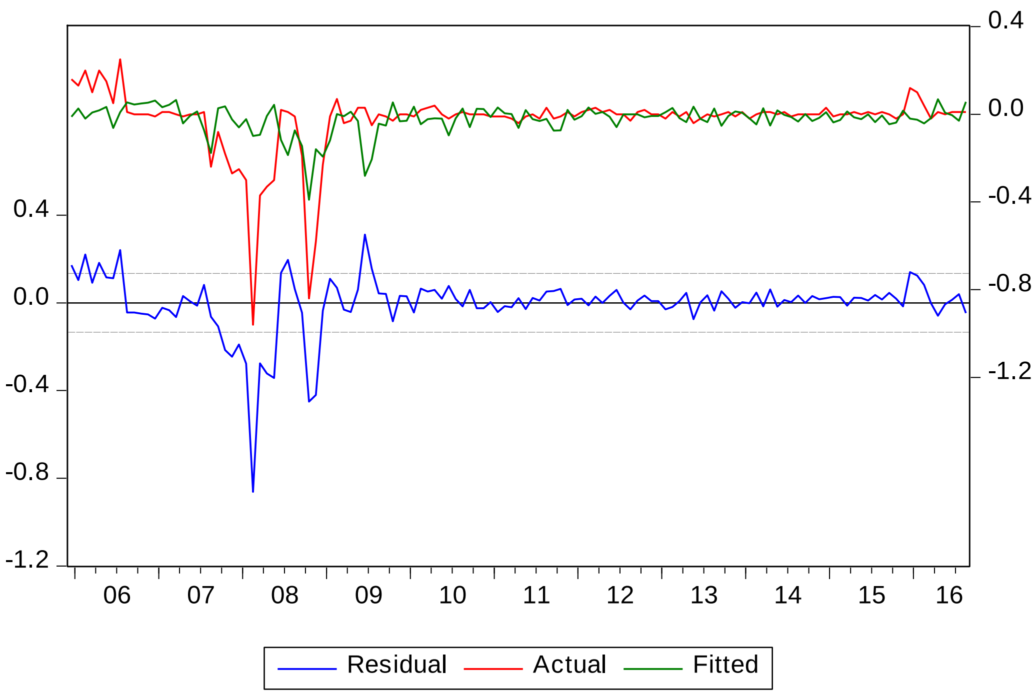

Illustration 3 – Regression Residuals

The EGARCH models the logarithm of the variance (or standard deviation) as a function of the lagged log(variance) and the lagged absolute error from the regression model. It also allows the response to the lagged error to be asymmetric, so that positive regression residuals can have a different effect on variance than an equivalent negative residual. Following Nelson (1991), let Z_t denote a series of independent and identically distributed standardized random variables with expectation 0 and variance 1, the EGARCH model is of the form:

$$\log \sigma_t^2 = \beta_1 + \sum_{k=1}^{\infty} \beta_k g(Z_{t-k})$$

Where β_1 and β_k are deterministic coefficients.

$$g(Z_t) = \theta Z_t + \gamma(|Z_t| - E|Z_t|)$$

$$E[g(Z_t)] = 0$$

As indicated in Table 10 below, an ARCH effect exist in the model since observed R-squared has a significant probability of 0.91%.

Table 10 – ARCH Test

Heteroskedasticity Test: ARCH

F-statistic	7.071249	Prob. F(1,126)	0.0089
Obs*R-squared	6.801769	Prob. Chi-Square(1)	0.0091

Test Equation:
Dependent Variable: RESID^2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.013271	0.006353	2.088831	0.0387
RESID^2(-1)	0.230535	0.086694	2.659182	0.0089

Table 11 – EGARCH Test

Dependent Variable: D(FEDFUNDS)
Method: ML ARCH - Generalized error distribution (GED) (BFGS / Marquardt steps)
GED parameter fixed at 2
LOG(GARCH) = C(4) + C(5)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(6)*RESID(-1)/@SQRT(GARCH(-1)) + C(7)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.003772	0.001040	-3.627773	0.0003
D(LOG(CDS))	-0.080707	0.004985	-16.19073	0.0000
AR(8)	-0.076794	0.008415	-9.125477	0.0000
		Variance Equation		
C(4)	-5.244092	0.396713	-13.21886	0.0000
C(5)	2.253551	0.182905	12.32086	0.0000
C(6)	-1.003355	0.187593	-5.348577	0.0000
C(7)	0.436447	0.058005	7.524311	0.0000

Persistency is the tendency of time series data to converge to its long run value. The persistence parameter, C(7), is small, implying that the variance moves rapidly through time. The asymmetry coefficient, C(6), is negative and significant, implying that the variance goes up more after negative residuals than after positive residuals. Also a negative C(6) suggests that volatility in the short-term interest rates can react asymmetrically to good and bad news in CDS rates.

Impulse Response Analysis - Vector Auto-regression (VAR) Modeling

For a bivariate function, VAR(p) is given by the following models:

$$Y_t = c_1 + \alpha_{11} Y_{t-1} + \alpha_{12} Y_{t-2} + \ldots + \alpha_{1p} Y_{t-p} + \beta_{11} X_{t-1} + \beta_{12} X_{t-2} + \ldots + \beta_{1p} X_{t-p} + \varepsilon_{1t} \qquad (1)$$

$$X_t = c_2 + \alpha_{21} Y_{t-1} + \alpha_{22} Y_{t-2} + \ldots + \alpha_{2p} Y_{t-p} + \beta_{21} X_{t-1} + \beta_{22} X_{t-2} + \ldots + \beta_{2p} X_{t-p} + \varepsilon_{2t} \qquad (2)$$

To examine causal interactions between the short-term interest rates and CDS rates, VAR and accumulated impulse response functions were analyzed with Monte Carlo distribution errors that are carried over 10 months. The Accumulated Response to Cholesky One S.D. Innovations ±2 S.E. interactions are shown in Illustrations 3, 4 and 5. From the Illustrations, the short-term interest rate appreciates when CDS rates increases, with a 2-month optimum impact lag. Also, the short-term interest rates depreciate when the inflation increases with a similar 2-month response lag. Lastly short-term interest rates appreciate when unemployment increases with a 2-month optimum impact lag. These impulse response functions confirm the robustness of the OLS and EGARCH regressions.

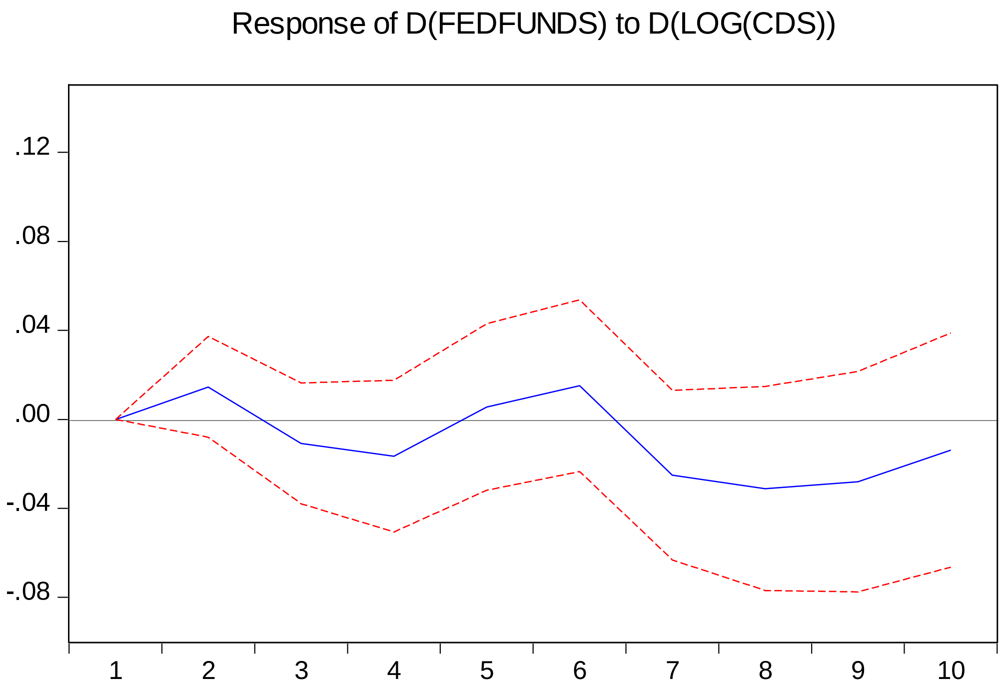

Illustration 3 - Accumulated Response of D(FEDFUNDS) to Dlog(USDEURO)

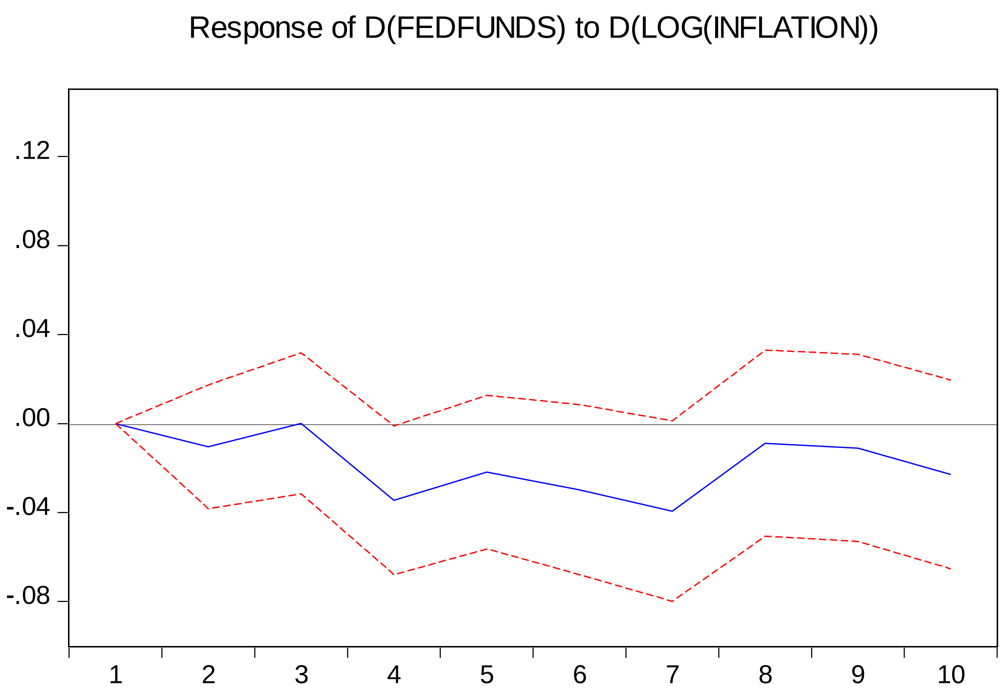

Illustration 4 - Accumulated Response of D(FEDFUNDS) to Dlog(INFLATION)

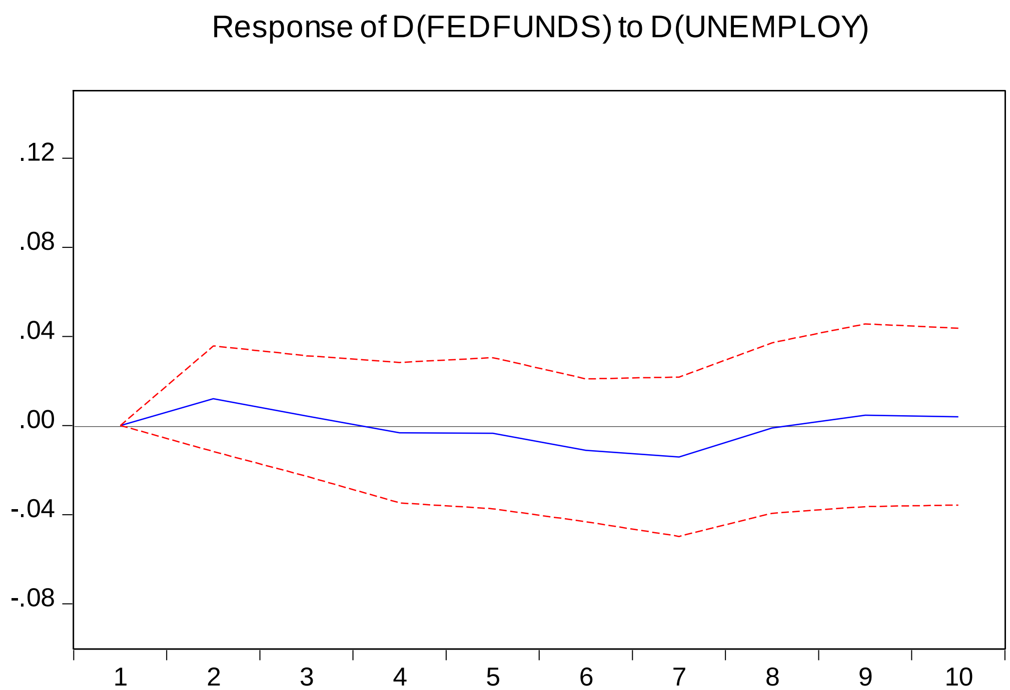

Illustration 5 - Accumulated Response of D(FEDFUNDS) to D(UNEMPLOY)

5.0 CONCLUSION AND POLICY IMPLICATIONS

This study examines the impact of CDS rates on short term interest rates policy. The aim of the paper is to provide a fresh contribution to literature by investigating data from 2005 to 2016.

In summary, utilizing monthly time series data from 2005 to 2016, I conducted conventional regression [OLS], auto-regression, co-integration, VECM, ARCH/EGARCH and VAR analyses. From the OLS analyses, CDS rates appear to have a negative relationship with short-term interest rates. OLS with auto-regression, AR(8), improves this model with a slightly higher R-squared. AR(8) accounts for about 39% persistency. An EGARCH(1,1) specification fits the time series very well. From the VAR analysis with Monte Carlo distribution of errors that are carried over a ten-month period, short-term interest rates depreciate when CDS rates appreciate thereby confirming the robustness of the OLS and EGARCH analyses.

I conclude that there is evidence with regards to an impact of CDS rates on the short-term interest rates policy. The major policy implication of this study is that credit default swap rates appear to impact short-term interest rates. Thus, Central Banks need to conduct regular revision of policy targeting framework and instruments to capture the continual changes in CDS rates.

Even though there exists evidence with regards to CDS rates impacting short-term interest rates, the current study may have left out some important control variables. One such variable is output gap. The International Monetary Fund defines output gap as "an economic measure of the difference between the actual output of an economy and its potential output". Thus, output gap measures the extent of inflation in an economy and can play a central role in policymaking. A study with output gap as an additional control variable is suggested for future research.

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APPENDIX – Modeling Outputs

Ordinary Least Squares Regression (OLS)

Dependent Variable: D(FEDFUNDS)
Method: Least Squares
Date: 03/09/17 Time: 04:39
Sample (adjusted): 2005M12 2016M08
Included observations: 129 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.026913	0.012654	-2.126832	0.0354
D(LOG(CDS))	-0.320065	0.089279	-3.585002	0.0005

R-squared	0.091899	Mean dependent var	-0.027907
Adjusted R-squared	0.084748	S.D. dependent var	0.150191
S.E. of regression	0.143686	Akaike info criterion	-1.026993
Sum squared resid	2.621993	Schwarz criterion	-0.982655
Log likelihood	68.24105	Hannan-Quinn criter.	-1.008978
F-statistic	12.85224	Durbin-Watson stat	0.809417
Prob(F-statistic)	0.000479		

OLS + AUTO-REGRESSION

Dependent Variable: D(FEDFUNDS)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 03/09/17 Time: 08:18
Sample: 2005M12 2016M08
Included observations: 129
Convergence achieved after 74 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.019270	0.025787	-0.747252	0.4563
D(LOG(CDS))	-0.244926	0.064830	-3.777970	0.0002
AR(8)	0.385432	0.041007	9.399186	0.0000
SIGMASQ	0.017404	0.001319	13.19256	0.0000

R-squared	0.222428	Mean dependent var	-0.027907
Adjusted R-squared	0.203766	S.D. dependent var	0.150191
S.E. of regression	0.134018	Akaike info criterion	-1.141191
Sum squared resid	2.245112	Schwarz criterion	-1.052515
Log likelihood	77.60682	Hannan-Quinn criter.	-1.105160
F-statistic	11.91891	Durbin-Watson stat	0.818192
Prob(F-statistic)	0.000001		

Inverted AR Roots	.89	.63+.63i	.63-.63i	.00-.89i
	-.00+.89i	-.63-.63i	-.63-.63i	-.89

Controlling for Inflation and Unemployment

Dependent Variable: D(FEDFUNDS)
Method: Least Squares
Date: 03/09/17 Time: 04:43
Sample (adjusted): 2005M12 2016M08
Included observations: 129 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.032765	0.013078	-2.505301	0.0135
D(LOG(CDS))	-0.268832	0.092634	-2.902097	0.0044
D(LOG(INFLATION))	4.013502	2.436160	1.647471	0.1020
D(UNEMPLOY)	0.096136	0.128961	0.745464	0.4574

R-squared	0.117855	Mean dependent var	-0.027907
Adjusted R-squared	0.096684	S.D. dependent var	0.150191
S.E. of regression	0.142746	Akaike info criterion	-1.024985
Sum squared resid	2.547048	Schwarz criterion	-0.936308
Log likelihood	70.11152	Hannan-Quinn criter.	-0.988954
F-statistic	5.566688	Durbin-Watson stat	0.800751
Prob(F-statistic)	0.001284		

Dependent Variable: D(FEDFUNDS)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 03/09/17 Time: 08:37
Sample: 2005M12 2016M08
Included observations: 129
Convergence achieved after 59 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.024431	0.026857	-0.909646	0.3648
D(LOG(CDS))	-0.199613	0.064599	-3.090009	0.0025
D(LOG(INFLATION))	3.444731	1.464968	2.351404	0.0203
D(UNEMPLOY)	0.048748	0.165627	0.294326	0.7690
AR(8)	0.387079	0.048771	7.936669	0.0000
SIGMASQ	0.016929	0.001280	13.22249	0.0000

R-squared	0.243639	Mean dependent var	-0.027907
Adjusted R-squared	0.212892	S.D. dependent var	0.150191
S.E. of regression	0.133248	Akaike info criterion	-1.137748
Sum squared resid	2.183868	Schwarz criterion	-1.004734
Log likelihood	79.38476	Hannan-Quinn criter.	-1.083702
F-statistic	7.924146	Durbin-Watson stat	0.799709
Prob(F-statistic)	0.000002		

Inverted AR Roots	.89	.63-.63i	.63+.63i	-.00-.89i
	-.00+.89i	-.63-.63i	-.63-.63i	-.89

Co-integration test

Date: 03/04/17 Time: 09:35
Sample (adjusted): 2007M01 2016M08
Included observations: 116 after adjustments
Trend assumption: Linear deterministic trend
Series: FEDFUNDS LOG(CDS)
Lags interval (in first differences): 1 to 13

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.108219	18.51147	15.49471	0.0170
At most 1 *	0.044048	5.225505	3.841466	0.0223

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.108219	13.28597	14.26460	0.0709
At most 1 *	0.044048	5.225505	3.841466	0.0223

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

FEDFUNDS	LOG(CDS)
-0.314751	2.770774
-1.035504	-5.200112

Unrestricted Adjustment Coefficients (alpha):

D(FEDFUNDS)	0.025073	0.007334
D(LOG(CDS))	-0.029537	0.017088

1 Cointegrating Equation(s): Log likelihood 219.5317

Normalized cointegrating coefficients (standard error in parentheses)

FEDFUNDS	LOG(CDS)
1.000000	-8.803063
	(4.04771)

Adjustment coefficients (standard error in parentheses)

D(FEDFUNDS)	-0.007892
	(0.00268)
D(LOG(CDS))	0.009297

	(0.00394)

Vector Error Correction Modeling (VECM)

Vector Error Correction Estimates
Date: 03/04/17 Time: 10:11
Sample (adjusted): 2007M01 2016M08
Included observations: 116 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
FEDFUNDS(-1)	1.000000	
LOG(CDS(-1))	-8.803063	
	(4.04771)	
	[-2.17483]	
C	38.54354	
Error Correction:	**D(FEDFUNDS)**	**D(LOG(CDS))**
CointEq1	-0.007892	0.009297
	(0.00268)	(0.00394)
	[-2.93971]	[2.35712]
D(FEDFUNDS(-1))	0.678531	-0.486361
	(0.11240)	(0.16514)
	[6.03687]	[-2.94521]
D(FEDFUNDS(-2))	0.015807	0.113770
	(0.12228)	(0.17965)
	[0.12927]	[0.63327]
D(FEDFUNDS(-3))	-0.096777	0.305979
	(0.12015)	(0.17653)
	[-0.80545]	[1.73332]
D(FEDFUNDS(-4))	-0.232853	-0.218402
	(0.12019)	(0.17659)
	[-1.93735]	[-1.23680]
D(FEDFUNDS(-5))	0.390975	-0.216406
	(0.12445)	(0.18285)
	[3.14155]	[-1.18353]
D(FEDFUNDS(-6))	0.009395	0.233870
	(0.12026)	(0.17668)
	[0.07813]	[1.32368]
D(FEDFUNDS(-7))	-0.482566	-0.109850

	(0.11300)	(0.16602)
	[-4.27039]	[-0.66165]
D(FEDFUNDS(-8))	0.515521	-0.109064
	(0.12672)	(0.18618)
	[4.06809]	[-0.58579]
D(FEDFUNDS(-9))	0.116378	0.064081
	(0.12436)	(0.18270)
	[0.93585]	[0.35074]
D(FEDFUNDS(-10))	-0.085127	0.069730
	(0.11907)	(0.17495)
	[-0.71490]	[0.39858]
D(FEDFUNDS(-11))	-0.180147	-0.313161
	(0.11526)	(0.16934)
	[-1.56297]	[-1.84930]
D(FEDFUNDS(-12))	0.396795	0.046423
	(0.11975)	(0.17594)
	[3.31353]	[0.26386]
D(FEDFUNDS(-13))	-0.110059	0.125119
	(0.10759)	(0.15808)
	[-1.02293]	[0.79151]
D(LOG(CDS(-1)))	0.050096	-0.083573
	(0.07700)	(0.11313)
	[0.65059]	[-0.73873]
D(LOG(CDS(-2)))	-0.138289	-0.195635
	(0.07221)	(0.10609)
	[-1.91516]	[-1.84407]
D(LOG(CDS(-3)))	-0.073632	-0.003920
	(0.07587)	(0.11147)
	[-0.97050]	[-0.03516]
D(LOG(CDS(-4)))	0.061503	-0.038690
	(0.07586)	(0.11145)
	[0.81077]	[-0.34715]
D(LOG(CDS(-5)))	0.089172	0.020727
	(0.07705)	(0.11320)
	[1.15735]	[0.18309]
D(LOG(CDS(-6)))	-0.260816	0.027146
	(0.07754)	(0.11392)
	[-3.36380]	[0.23829]
D(LOG(CDS(-7)))	-0.104561	-0.044825
	(0.08222)	(0.12079)
	[-1.27179]	[-0.37109]
D(LOG(CDS(-8)))	-0.052034	0.000499
	(0.07687)	(0.11294)

	[-0.67688]	[0.00442]
D(LOG(CDS(-9)))	-0.072500	-0.145485
	(0.07721)	(0.11345)
	[-0.93894]	[-1.28243]
D(LOG(CDS(-10)))	-0.022827	-0.050295
	(0.07825)	(0.11496)
	[-0.29174]	[-0.43749]
D(LOG(CDS(-11)))	0.103154	-0.183037
	(0.07874)	(0.11569)
	[1.31006]	[-1.58220]
D(LOG(CDS(-12)))	0.182121	0.108222
	(0.07632)	(0.11213)
	[2.38634]	[0.96517]
D(LOG(CDS(-13)))	-0.051856	-0.019536
	(0.07942)	(0.11668)
	[-0.65295]	[-0.16743]
C	-0.001059	-0.010429
	(0.00997)	(0.01465)
	[-0.10625]	[-0.71194]
R-squared	0.710570	0.339843
Adj. R-squared	0.621767	0.137295
Sum sq. resids	0.742579	1.602921
S.E. equation	0.091861	0.134963
F-statistic	8.001685	1.677840
Log likelihood	128.3737	83.74537
Akaike AIC	-1.730581	-0.961127
Schwarz SC	-1.065921	-0.296467
Mean dependent	-0.041724	0.006494
S.D. dependent	0.149365	0.145306
Determinant resid covariance (dof adj.)		0.000135
Determinant resid covariance		7.78E-05
Log likelihood		219.5317
Akaike information criterion		-2.785029
Schwarz criterion		-1.408234

Dependent Variable: D(FEDFUNDS)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 03/04/17 Time: 10:23
Sample (adjusted): 2007M01 2016M08
Included observations: 116 after adjustments
D(FEDFUNDS) = C(1)*(FEDFUNDS(-1) - 8.80306271734*LOG(CDS(-1)) + 38.5435394264) + C(2)*D(FEDFUNDS(-1)) + C(3)*D(FEDFUNDS(-2)) + C(4)*D(FEDFUNDS(-3)) + C(5)*D(FEDFUNDS(-4)) + C(6) *D(FEDFUNDS(-5)) + C(7)*D(FEDFUNDS(-6)) + C(8)*D(FEDFUNDS(-7)) + C(9)*D(FEDFUNDS(-8)) + C(10)*D(FEDFUNDS(-9)) + C(11) *D(FEDFUNDS(-10)) + C(12)*D(FEDFUNDS(-11)) + C(13) *D(FEDFUNDS(-12)) + C(14)*D(FEDFUNDS(-13)) + C(15) *D(LOG(CDS(-1))) + C(16)*D(LOG(CDS(-2))) + C(17)*D(LOG(CDS(-3))) + C(18)*D(LOG(CDS(-4))) + C(19)*D(LOG(CDS(-5))) + C(20) *D(LOG(CDS(-6))) + C(21)*D(LOG(CDS(-7))) + C(22)*D(LOG(CDS(-8))) + C(23)*D(LOG(CDS(-9))) + C(24)*D(LOG(CDS(-10))) + C(25) *D(LOG(CDS(-11))) + C(26)*D(LOG(CDS(-12))) + C(27)*D(LOG(CDS(-13))) + C(28)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.007892	0.002685	-2.939708	0.0042
C(2)	0.678531	0.112398	6.036871	0.0000
C(3)	0.015807	0.122279	0.129266	0.8974
C(4)	-0.096777	0.120151	-0.805455	0.4227
C(5)	-0.232853	0.120191	-1.937355	0.0559
C(6)	0.390975	0.124453	3.141545	0.0023
C(7)	0.009395	0.120256	0.078126	0.9379
C(8)	-0.482566	0.113003	-4.270393	0.0000
C(9)	0.515521	0.126723	4.068095	0.0001
C(10)	0.116378	0.124356	0.935846	0.3519
C(11)	-0.085127	0.119074	-0.714905	0.4766
C(12)	-0.180147	0.115259	-1.562971	0.1216
C(13)	0.396795	0.119750	3.313526	0.0013
C(14)	-0.110059	0.107593	-1.022926	0.3091
C(15)	0.050096	0.077001	0.650591	0.5170
C(16)	-0.138289	0.072208	-1.915159	0.0587
C(17)	-0.073632	0.075870	-0.970502	0.3345
C(18)	0.061503	0.075857	0.810775	0.4197
C(19)	0.089172	0.077049	1.157346	0.2503
C(20)	-0.260816	0.077536	-3.363795	0.0011
C(21)	-0.104561	0.082216	-1.271786	0.2068
C(22)	-0.052034	0.076873	-0.676880	0.5003
C(23)	-0.072500	0.077215	-0.938936	0.3503
C(24)	-0.022827	0.078246	-0.291739	0.7712
C(25)	0.103154	0.078739	1.310065	0.1936
C(26)	0.182121	0.076318	2.386342	0.0192
C(27)	-0.051856	0.079419	-0.652947	0.5155
C(28)	-0.001059	0.009971	-0.106253	0.9156

R-squared	0.710570	Mean dependent var	-0.041724
Adjusted R-squared	0.621767	S.D. dependent var	0.149365
S.E. of regression	0.091861	Akaike info criterion	-1.730581
Sum squared resid	0.742579	Schwarz criterion	-1.065921
Log likelihood	128.3737	Hannan-Quinn criter.	-1.460767
F-statistic	8.001685	Durbin-Watson stat	2.041119
Prob(F-statistic)	0.000000		

Wald Test: to check the short run causality from CDS to FFR

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2.968096	(13, 88)	0.0012
Chi-square	38.58524	13	0.0002

Null Hypothesis: C(15)=C(16)=C(17)=C(18)=C(19)=C(20)=
C(21)=C(22)=C(23)=C(24)=C(25)=C(26)=C(27)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(15)	0.050096	0.077001
C(16)	-0.138289	0.072208
C(17)	-0.073632	0.075870
C(18)	0.061503	0.075857
C(19)	0.089172	0.077049
C(20)	-0.260816	0.077536
C(21)	-0.104561	0.082216
C(22)	-0.052034	0.076873
C(23)	-0.072500	0.077215
C(24)	-0.022827	0.078246
C(25)	0.103154	0.078739
C(26)	0.182121	0.076318
C(27)	-0.051856	0.079419

Restrictions are linear in coefficients.

reject Null. C is not zero. There's a short run causality from CDS to FFR

Model Robustness Tests:

- Serial correlation
- Heteroskedascity
- Normal distribution

Serial correlation

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.915141	Prob. F(13,75)	0.5417
Obs*R-squared	15.88127	Prob. Chi-Square(13)	0.2556

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 03/04/17 Time: 10:53
Sample: 2007M01 2016M08
Included observations: 116
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.016470	0.045607	0.361132	0.7190
C(2)	1.626497	3.999792	0.406645	0.6854
C(3)	-0.901265	1.618777	-0.556757	0.5794
C(4)	-0.121966	0.627720	-0.194300	0.8465
C(5)	0.041094	0.390324	0.105282	0.9164
C(6)	0.492614	1.177178	0.418470	0.6768
C(7)	-0.386934	1.310324	-0.295296	0.7686
C(8)	-0.222324	0.482585	-0.460695	0.6464
C(9)	0.635092	1.863165	0.340868	0.7342
C(10)	-0.686670	1.575209	-0.435923	0.6641
C(11)	-0.119660	0.923584	-0.129561	0.8973
C(12)	0.099869	0.201022	0.496805	0.6208
C(13)	0.279200	0.809411	0.344942	0.7311
C(14)	-0.615439	1.376109	-0.447232	0.6560
C(15)	0.156886	0.414630	0.378376	0.7062
C(16)	0.000878	0.115496	0.007599	0.9940
C(17)	0.204423	0.552270	0.370151	0.7123
C(18)	0.176086	0.473263	0.372068	0.7109
C(19)	-0.065683	0.141507	-0.464168	0.6439
C(20)	-0.155216	0.408465	-0.379998	0.7050
C(21)	0.372809	0.943288	0.395223	0.6938
C(22)	0.302349	0.732098	0.412989	0.6808
C(23)	0.166982	0.442761	0.377139	0.7071
C(24)	0.077418	0.415440	0.186352	0.8527
C(25)	0.002115	0.250006	0.008459	0.9933
C(26)	-0.147506	0.344233	-0.428506	0.6695
C(27)	-0.250420	0.830524	-0.301521	0.7639
C(28)	0.001704	0.012106	0.140768	0.8884
RESID(-1)	-1.680566	4.048173	-0.415142	0.6792
RESID(-2)	-0.077191	1.222989	-0.063117	0.9498

RESID(-3)	-0.024021	0.488644	-0.049159	0.9609
RESID(-4)	0.027718	0.331386	0.083642	0.9336
RESID(-5)	-0.079511	0.332269	-0.239298	0.8115
RESID(-6)	-0.218586	0.241000	-0.906997	0.3673
RESID(-7)	-0.133812	0.220161	-0.607794	0.5452
RESID(-8)	0.129156	0.218205	0.591903	0.5557
RESID(-9)	0.232324	0.210867	1.101752	0.2741
RESID(-10)	-0.141155	0.206427	-0.683801	0.4962
RESID(-11)	-0.386975	0.205005	-1.887636	0.0629
RESID(-12)	-0.220992	0.197088	-1.121287	0.2657
RESID(-13)	0.183389	0.195590	0.937617	0.3515

R-squared	0.136907	Mean dependent var	-1.44E-18
Adjusted R-squared	-0.323409	S.D. dependent var	0.080357
S.E. of regression	0.092442	Akaike info criterion	-1.653677
Sum squared resid	0.640914	Schwarz criterion	-0.680425
Log likelihood	136.9132	Hannan-Quinn criter.	-1.258592
F-statistic	0.297421	Durbin-Watson stat	1.997577
Prob(F-statistic)	0.999967		

No serial correlation

Heteroskedascity

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.542774	Prob. F(28,87)	0.0660
Obs*R-squared	38.48709	Prob. Chi-Square(28)	0.0895
Scaled explained SS	154.6612	Prob. Chi-Square(28)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/04/17 Time: 10:56
Sample: 2007M01 2016M08
Included observations: 116

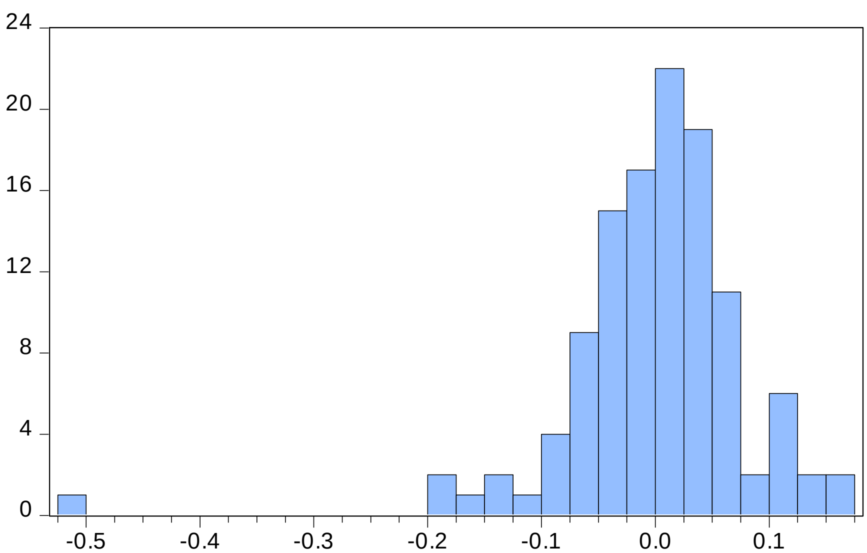
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004548	0.012094	0.376018	0.7078
FEDFUNDS(-1)	-0.057666	0.026568	-2.170500	0.0327
CDS(-1)	-0.000234	0.000195	-1.197902	0.2342
FEDFUNDS(-2)	0.038664	0.048129	0.803328	0.4240
FEDFUNDS(-3)	0.033827	0.049347	0.685495	0.4949
FEDFUNDS(-4)	1.32E-05	0.049310	0.000267	0.9998
FEDFUNDS(-5)	-0.009856	0.051175	-0.192594	0.8477
FEDFUNDS(-6)	-0.079187	0.053077	-1.491919	0.1393
FEDFUNDS(-7)	0.178442	0.049881	3.577375	0.0006
FEDFUNDS(-8)	-0.109192	0.051334	-2.127082	0.0362
FEDFUNDS(-9)	-0.016548	0.055731	-0.296933	0.7672
FEDFUNDS(-10)	0.002937	0.051560	0.056957	0.9547
FEDFUNDS(-11)	0.065450	0.051910	1.260842	0.2107
FEDFUNDS(-12)	-0.028631	0.050826	-0.563319	0.5747

FEDFUNDS(-13)	-0.057764	0.051577	-1.119948	0.2658
FEDFUNDS(-14)	0.041990	0.028917	1.452093	0.1501
CDS(-2)	0.000209	0.000253	0.822869	0.4128
CDS(-3)	-7.45E-05	0.000249	-0.298926	0.7657
CDS(-4)	-9.36E-05	0.000251	-0.373003	0.7101
CDS(-5)	-0.000173	0.000262	-0.659298	0.5114
CDS(-6)	0.000911	0.000266	3.430792	0.0009
CDS(-7)	-0.000252	0.000281	-0.897540	0.3719
CDS(-8)	-0.000373	0.000268	-1.390420	0.1679
CDS(-9)	-0.000193	0.000249	-0.771923	0.4423
CDS(-10)	0.000210	0.000248	0.844860	0.4005
CDS(-11)	0.000140	0.000244	0.574719	0.5670
CDS(-12)	-0.000129	0.000234	-0.548927	0.5845
CDS(-13)	4.26E-05	0.000232	0.183739	0.8546
CDS(-14)	-2.23E-05	0.000179	-0.125094	0.9007

R-squared	0.331785	Mean dependent var	0.006402
Adjusted R-squared	0.116728	S.D. dependent var	0.024026
S.E. of regression	0.022581	Akaike info criterion	-4.531135
Sum squared resid	0.044360	Schwarz criterion	-3.842737
Log likelihood	291.8058	Hannan-Quinn criter.	-4.251685
F-statistic	1.542774	Durbin-Watson stat	2.337389
Prob(F-statistic)	0.066030		

No Heteroskedascity

Normal



Series: Residuals	
Sample 2007M01 2016M08	
Observations 116	
Mean	-1.44e-18
Median	0.004720
Maximum	0.172574
Minimum	-0.501431
Std. Dev.	0.080357
Skewness	-2.112997
Kurtosis	14.96519
Jarque-Bera	778.2863
Probability	0.000000

Not normally distributed

ARCH/EGARCH

Heteroskedasticity Test: ARCH

F-statistic	7.071249	Prob. F(1,126)	0.0089
Obs*R-squared	6.801769	Prob. Chi-Square(1)	0.0091

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/09/17 Time: 11:15
Sample (adjusted): 2006M01 2016M08
Included observations: 128 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.013271	0.006353	2.088831	0.0387
RESID^2(-1)	0.230535	0.086694	2.659182	0.0089

R-squared	0.053139	Mean dependent var	0.017311
Adjusted R-squared	0.045624	S.D. dependent var	0.071446
S.E. of regression	0.069797	Akaike info criterion	-2.470959
Sum squared resid	0.613819	Schwarz criterion	-2.426396
Log likelihood	160.1414	Hannan-Quinn criter.	-2.452853
F-statistic	7.071249	Durbin-Watson stat	2.050538
Prob(F-statistic)	0.008850		

Dependent Variable: D(FEDFUNDS)
Method: ML ARCH - Generalized error distribution (GED) (BFGS / Marquardt steps)
Date: 03/09/17 Time: 11:19
Sample (adjusted): 2006M08 2016M08
Included observations: 121 after adjustments
Convergence achieved after 59 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GED parameter fixed at 2
LOG(GARCH) = C(4) + C(5)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(6)*RESID(-1)/@SQRT(GARCH(-1)) + C(7)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.003772	0.001040	-3.627773	0.0003
D(LOG(CDS))	-0.080707	0.004985	-16.19073	0.0000
AR(8)	-0.076794	0.008415	-9.125477	0.0000
		Variance Equation		
C(4)	-5.244092	0.396713	-13.21886	0.0000
C(5)	2.253551	0.182905	12.32086	0.0000
C(6)	-1.003355	0.187593	-5.348577	0.0000
C(7)	0.436447	0.058005	7.524311	0.0000

R-squared	-0.094589	Mean dependent var	-0.040000
Adjusted R-squared	-0.113141	S.D. dependent var	0.146464
S.E. of regression	0.154527	Akaike info criterion	-3.497203
Sum squared resid	2.817690	Schwarz criterion	-3.335463
Log likelihood	218.5808	Hannan-Quinn criter.	-3.431514
Durbin-Watson stat	0.651871		

Inverted AR Roots	.67+.28i	.67-.28i	.28-.67i	.28+.67i
	-.28-.67i	-.28+.67i	-.67-.28i	-.67+.28i